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*Published in:*

Proceedings of the CIB World Building Congress 2019

*Publication date:*

2019

*Document Version*

Peer reviewed version

[Link to publication in ResearchOnline](#)

*Citation for published version (Harvard):*

Mickovski, SB & McKeever, M 2019, BIM awareness, knowledge, and implementation within a multi-disciplinary design consultancy in Scotland. in *Proceedings of the CIB World Building Congress 2019.*, 1240, pp. 1232.

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# BIM awareness, knowledge, and implementation within a multi-disciplinary design consultancy in Scotland

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## Abstract

Building Information Modelling (BIM) is a relatively new concept in the UK construction industry. Born in recent years, and mandated by the Scottish Government in 2017, this concept has become an extremely relevant topic and the infrastructure and the government industry is still coming to grips with its utilisation, especially with the initiative for all centrally-funded projects to utilise BIM as a design tool. The aim of this paper is to investigate the levels of awareness, knowledge and implementation of BIM within the construction industry in Scotland in order to benchmark against the predicted and desired levels of maturity at UK level. To achieve this aim, we surveyed a broad spectrum of construction professionals from Scotland using structured cross-sectional questionnaire surveys and semi-structured personal interviews. The results of the survey show that despite the relatively high level of awareness, the knowledge of BIM processes and methodologies is lagging behind the expected and predicted levels. The implementation of BIM within a major multi-disciplinary consultancy was shown to be subject to a number of barriers apparent at UK level. Respondents identified education, advertisement and leadership from the Scottish Government as the areas necessitating enhancement. Additionally, the professional bodies, academic institutions and the major industry enterprises were identified as leaders and drivers for the future of BIM. The lessons learned from this survey in Scotland can be used in double loop learning for comparable countries in the world, but also as a baseline to benchmark future BIM developments in the construction industry in the UK.

**Keywords:** BIM, knowledge, implementation, infrastructure, building.

## 1. Introduction

BIM is considered a more efficient and collaborative way of coordinating construction project information, utilizing an information-rich 3D model together with the latest advances in technology. It can be used as an effective tool throughout the lifecycle project to bill, review construction processes, generate material orders and to inform facilities management after construction is complete. Given its effectiveness, the UK and Scottish governments are mandating its use since 2016 and 2017, respectively, as a response to the increased pressure on public spending, continued development of national infrastructure in the future, and increasing regulation and policies to reduce carbon emissions and resource consumption (Matthews, 2016). The construction industry in the UK has suffered years of underinvestment with a need for development of IT systems and capabilities that reflect other industries and enhance productivity and efficiency while reducing errors and waste over project lifecycle.

Although the BIM awareness and usage are increasing, there are still some common misconceptions of the process, perhaps due to the fact that its application is still in infancy within the construction industry. Therefore, it is important that designers, contractors and perhaps, most importantly, clients

to understand its definition and implications as they would ultimately decide whether they want a project completed using the BIM process and to what level they wish the information to be provided. According to the BIM maturity description (PAS 1192-2, 2013) the BIM Level 0 (or pre-BIM) comprises the use of 2D CAD to produce drawing information, with which the industry embraces significant barriers and inefficiencies (Khosrowshahi and Arayici, 2012) because of lack of sharing electronic information within a common data environment (CDE). BIM Level 1 involves the use of 2D and 3D information and, despite signs of increased collaboration, only some of the design team may use the 3D models while the BIM model is still single-disciplinary and the deliverables are mostly CAD-like documents. BIM Level 2 signifies the progress from modelling towards collaboration and interoperability (Khosrowshahi and Arayici, 2012) with requirement that the current fragmentation of the design team is replaced by Integrated Teams working collaboratively under new forms of procurement (RIBA, 2013).

Due to the mandated use and governmental backing, there has been a flurry of activities in the UK with the construction industry trying to define standards and management processes to help meet demands and educate the industry to work at BIM Level 2. UK-based companies have started to develop their own policies and procedures to ensure compliance with the latest legislation, but also to show leadership in BIM development which would ensure larger proportion of the market share – e.g. AECOM's 'The BIM Playbook' or Arup's 'BIM Maturity Measure' – but their application within and outwith the company has not been measured. On the other hand, the National Building Specification (NBS) stated in their BIM reports (2016-2018) that there has been continuous growth as the proportion of practices has significantly increased since BIM has been mandated. However, with the BIM being introduced in Scotland a year later, the awareness of the current best practice and standards, as well as the level of adoption remain masked under the UK average and is difficult to monitor.

In response to governmental mandate, a series of Publicly Available Specification (PAS) documents are being developed to set out the requirements for achieving BIM Level 2 by establishing a framework for collaborative working and information requirements. They are developed to meet an immediate market need and follow guidelines set out by the British Standards Institution (BSI) with a view of revision and assessment after two years to determine if they require revision, should be withdrawn or become formal British or international standards. Along with the PAS, the Construction Industry Council have produced BIM Protocol (2<sup>nd</sup> ed published in 2018) which remains the only standard contractual BIM protocol published in the UK, applies to models and information (including security), and can be used alongside a range of different contractual arrangements. The past few years saw a number of handbooks and guides being developed to assist with the adoption and implementation of BIM for organizations and projects not only in UK but also internationally. Aimed at clarification and interpretation of the BIM standards, these publications, also contributed towards increasing ambiguity and uncertainty among the practitioners. As a result of this, BIM specialist roles may be developing in an uncoordinated manner, even when companies and individuals consider themselves to be following best practice guidance (Davies et al 2017).

In terms of BIM deliverables, the current legislation covers Employers Information Requirements (EIR) as the basis of BIM application on a project which can be part of wider suite of documents produced during procurement and are critical to delivering to the client's needs (PAS 1192, 2013). To reinforce this, a BIM Execution Plan (BEP) is usually also developed to ensure that the project design team will execute the project as agreed, meeting the client and industry requirements (CPIC, 2016) in terms of modelling strategy and objectives, software use, drawings standards, information workflows, and information for inclusion at handover (AECOM, 2014). In order to enable the BIM process as laid out in the preceding documents, a Common Data Environment (CDE) needs to be set up and allow the project teams to use and share project information safely and securely. The level of this information, both material and element, at BIM Level 2 should be in a format which everyone on the project should be able to access and understand and, for this purpose, a Construction Operation Building Information Exchange (COBIE) data needs to be collated in a 'neutral format that is fast becoming the de-facto standard for rich data exchange' (Mordue, 2013). The above concepts are central to BIM

application and delivery but it is not clear to what level of detail they are introduced and clarified with the design teams who are in charge of the project delivery.

The aim of this study is to investigate the BIM capabilities and level of understanding within the Scottish offices of a multi-disciplinary design consultancy shortly after the BIM Level 2 mandate for public sector project has been introduced. The objectives of this study include identification of the main reasons for adoption for BIM, identification of the codes of practice and industry strategies currently used in BIM-related projects, evaluation of the implementation and perception of BIM within a multi-disciplinary Scotland-based consultancy, as well as identification of personal and organizational barriers to BIM Level 2 achievement.

## **2. Materials and Methods**

A structured questionnaire survey was administered within a large, multi-disciplinary civil engineering consultancy in Scotland using the company's intranet platform. Using a Likert-type scale, survey respondents were requested to provide opinions on their awareness of current status and issues surrounding BIM adoption and usage in their day-to-day work. The respondents were also requested to provide opinion on the BIM adoption process since the government mandated its implementation as well as their views on the future of BIM implementation within their organization. The responses from sampled respondents were gathered manually, transcribed in a spreadsheet format, anonymized, and stored on a secure hard drive. A total of 602 questionnaires were issued, a number reflecting the number of employees in a multi-disciplinary consultancy based in Scotland.

Interviews with key BIM adopters within the consultancy and academia (Glasgow Caledonian University) took place to confirm the content and questions in the survey. A pilot and three semi-structured interviews were carried out before the survey was conducted with staff of varying experience of BIM to ensure that a unvarying understanding of the issues and content of the questionnaire was achieved.

## **3. Results and analysis**

The questionnaire survey resulted in 145 responses (26.4% response rate), out of which 53.1% were general and specialist civil engineers, 19.3% building and surveying professionals, 16.2% CAD and IT technicians, and 7.6% architects which broadly reflected the structure of a civil engineering consultancy. More than 64% of the respondents had between 0 and 15 years of experience in the construction industry which resulted in relatively high awareness (71.7%) but low utilisation (23.4%) of BIM (Figure 1).

Both figures together roughly reflect the values recorded for the whole of the UK (96% for UK cf. 95% for Scotland), however the low utilisation recorded in this survey may reflect the fact that BIM was mandated in Scotland only in 2017 and a sharp rise in utilisation may be expected in the next few years. The low level of BIM utilisation is potentially due to the low level of awareness of the best practice and BIM codes (Figure 2).

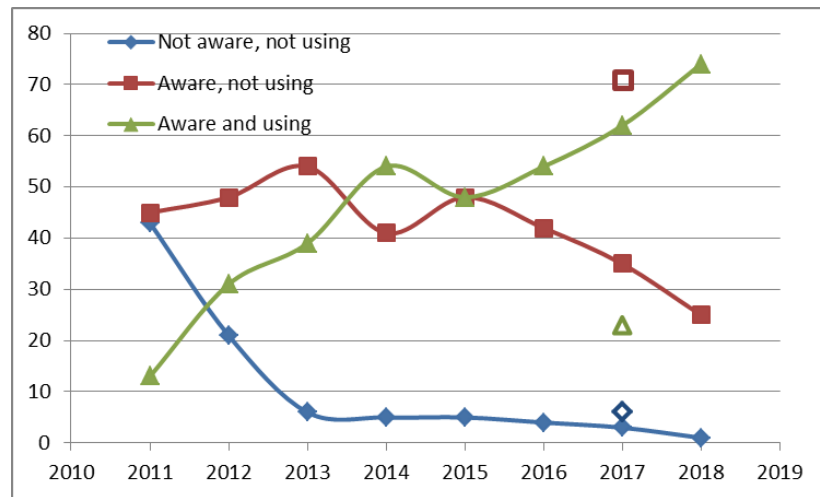


Figure 1 BIM adoption over time in the UK (line; Source: NBS, 2018) and among the surveyed in the current study (sole markers).

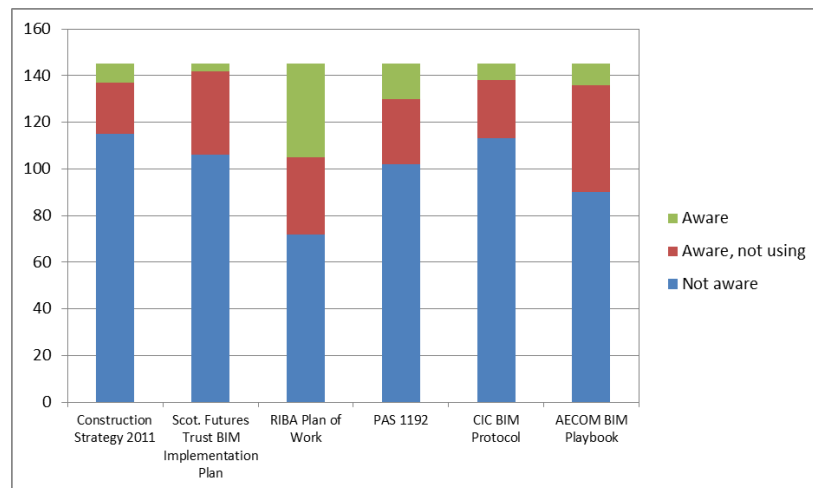


Figure 2 Level of awareness and utilisation of existing BIM best practice guidelines and codes.

The awareness of BIM levels in our survey was shown to be lower than the UK figures (56.6% cf. 77%), with the deliverables such as Master Delivery Information Plan (MDIP) and Employers Information Requirements (EIR) having the lowest levels of awareness amongst the employees (20% and 38%, respectively). The figures above may be reflective of the lack of exposure of technical and professional staff to clients and contract documents which would usually be a managerial or directorial responsibility.

In terms of current BIM –related practices, the respondents from our survey showed similar trends as recorded for the whole UK (Figure 3), with a notable good practice in sharing models across disciplines internally which reflects the structure of a large multi-national and multi-disciplinary consultancy. The fact that there is a little evidence of handing over the models to facilities management may be reflective of the current low level of awareness of certain BIM procedures as noted above as well as the relatively short period of mandatory BIM practice in Scotland – both visible in the response to the question of self-assessment of the highest BIM level the company has achieved (43% thought Level 1, and 44% of the respondents thought Level 2 to be the highest to-date). Higher awareness and utilisation of the BIM-enabling processes such as IFC (4.1% of the respondents have used it), and COBie (2.7% have used it) would certainly drive these figures closer to the UK levels (63% and 27%).

The general opinion on BIM expressed by the respondents (Figure 4), led to a closer investigation of the barriers to implementation through the open ended questions in the survey and semi-structured interviews. The main barrier perceived was the cost of implementation, followed by lack of in-house expertise, client demand, and relevance/appropriateness to the project size.

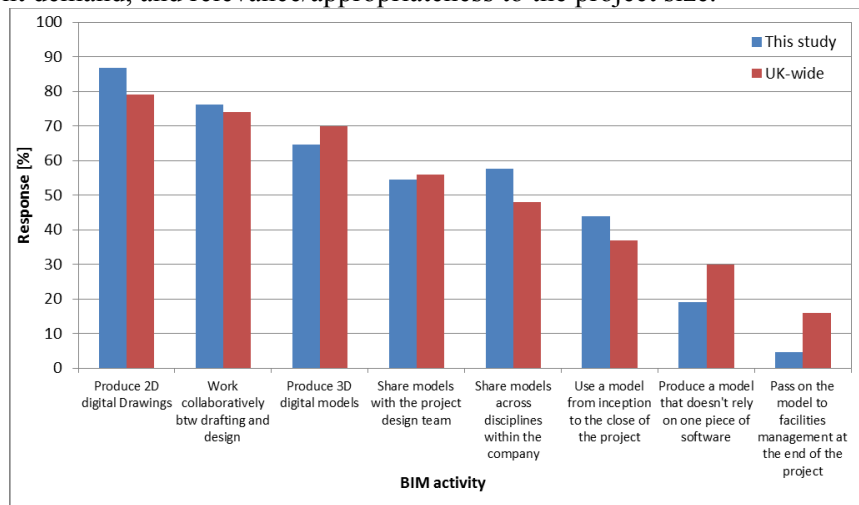


Figure 3 Most common current BIM activities within the respondents' department, compared to the UK-wide data (NBS, 2011).

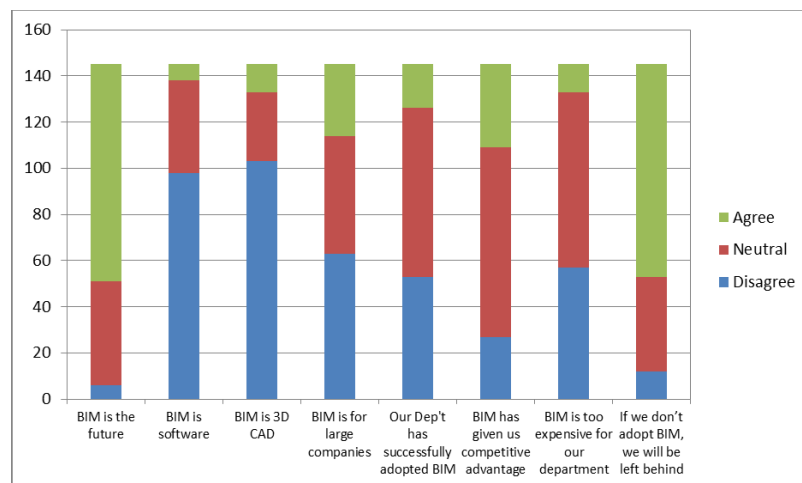


Figure 4 Respondents' opinions on BIM and potential barriers for its implementation.

The cost was expectably considered the main barrier for a business adopting a new way of working. One of the interviewees stated that 'In (their) line of work (water) and the size of project (small), there is generally little need for cross-discipline model editing and it is felt that a sufficiently detailed topo survey in a water environment together with the production of 3D drawings is too expensive for the simple things such as drains, channels or embankments' which echoes opinions expressed across the UK (NBS, 2018). Another interviewee stated 'I want to implement BIM but our fee winners never fee the job for this', which shows that the managers are currently not considering the extra time and effort that goes into the setup and running of the BIM processes. Although NBS (2018) reports that BIM can work on any size of project', our interviewees stated that some clients do not require any Level 2 BIM work, or when it is required, it is usually for the larger design-and-build projects where clash detection is critical: 'A lack of understanding of the requirements and processes on the client side has limited our ability to progress. The BIM success story within our team is a result of it being driven by the client'.

All of the interviewees agreed, however, that BIM implementation is a must for the large consultancies who, beyond the initial financial outlay, can recuperate the costs of implementation by winning work that smaller companies do not have capacity to win: '3D modelling is great for building structures. I can see true BIM being a good idea for very large projects such as airports and hospitals where there are complex building services, but otherwise the concept is 'oversold' to participants involved in small to medium projects – i.e. the alleged benefits will never be realized without a heavier time investment at design stage. No one wants to pay for this'. One of the interviewees stated their belief that the Scottish Government by mandating BIM implementation 'are making the market less competitive because smaller companies can't afford to keep up'. Because of this, another interviewee believed that 'BIM mandate may be too ambitious for the Government, similar to the Carbon 2020 targets'.

The lack of awareness, training and, ultimately, expertise within the company was recognised as one of the main barriers to implementation. One of the interviewees was convinced that 'there is a profit to be made, particularly for larger companies who can afford to provide BIM training and software' to their employees. All interviewees agreed that they are using BIM processes varying in maturity from Level 1 (basic 3D modelling and use of CDE; 43% of the surveyed cf. 22% in UK) to Level 2 (transfer of IFC formats and coordination of COBie data with a central model; 44% of the surveyed cf. 70% UK-wide) with an appropriate level of collaboration but also noted that these are restricted by the capabilities of the engineers within (different departments) and outwith their organisation (clients, consultants, contractors). Bearing in mind that Level 2 BIM is the foundation of the envisaged digital transformation of the construction industry (NBS, 2018) providing data structures, responsibilities and processes, it is clear that in order to enhance productivity and quality within the industry, there is a need for 'maturation' in terms of BIM levels in the construction industry in Scotland, i.e. a solid foundation on which future transformative technology (higher levels of BIM) can be built on. Several interviewees intimated that some training in form of a CPD was provided for software such as Revit or topics such as CDE, but felt that this was not enough for personal or departmental development and suggested that introductory and refresher CPD courses are run in-house as means of staying abreast with the latest BIM developments.

Contrary to the published literature (e.g. Race, 2013) where top management is expected to take the lead when a change in working practice is initiated, one of our interviewees believed that the technicians should lead the process, moving upwards through the BIM levels 1 and 2 with the development of the models. Other respondents stated that IT, software managers and departmental leads should take charge of the implementation by providing training opportunities and adequate working environment: 'It would likely need strong leadership to encourage everyone to learn to use it and then use it confidently on projects'; moreover 'A huge amount of training is required if the level of BIM currently being discussed and documented by the company (BIM Level 2) has to be used successfully by staff'. With such contrasting opinions, it is possible that gaps in communication and/or overlap of duties and responsibilities would occur within a department or company.

## **4. Discussion and conclusions**

The initial critical literature survey provided a background to the BIM process and allowed for definition of the most important elements that the industry must change to accommodate. It also provided basis for contrast to the UK figures (NBS, 2018) and for defining the topics explored in the questionnaire survey and the interviews where, promisingly, all of the interviewees were aware of different BIM levels yet none of them could define them properly. While the response rate was not as high as hoped for, it did allow for comparison with the UK averages and confirmed that the Scottish industry is lagging behind in adoption of the BIM processes. The overwhelming conclusion from the survey was that clash detection and traditional structural/civil engineering design via various BIM models largely outweighed the formatting of the data, preparation for its interoperability, and preparation for facilities management. This indicated, similarly as in published literature (Eadie et al.,

2015), that the focus of the industry lies in meeting the governmental targets and not exploiting BIM to its full potential.

While the wealth of ‘best practice’ information and variation in the use of codes of practice may create a future interoperability problem between BIM systems and users (Eadie et al., 2015), this study also revealed that there are disconnections between tactical and strategic level BIM implementation. Although BIM-enabling software has been introduced within Scotland, there was little evidence of other BIM Level 2 processes being adopted with the respondents – processes such as EIR and COBIE set up which require more strategic approach and coordination from the outset of the project. To remedy this, there have to be more comprehensive approach to BIM benefits capture that recognises the disconnection in order to usefully inform implementation strategy development (Dowset and Harty 2018).

One way to enhance the BIM practice by delivering value on a project but also build capacity within an organisation would be to adopt some form of external certification, perhaps under the UK accreditation Scheme (UKAS) like the one announced in 2016 (NBS, 2018) to support the UK Government’s Construction Strategy. Such certification is likely to add value both to the project and the BIM capability of both project and individual (NBS, 2018).

The BIM implementation obstacles identified in this study such as fragmentation, inertia, lack of training and unestablished designer-client relationships can be addressed using various people management strategies (Liao and Teo, 2018) which will help practitioners identify specific adjustments to their implementation activities. On the other hand, the survey and the interviews revealed that a change in business processes is required rather than just promoting technology when implementing BIM (Howard and Björk, 2008), a change which would be driven by a change in culture for everyone involved which will, ultimately, lead to a more sustainable way of working (Nawari, 2012).

It is suggested that a similar survey is conducted annually to measure the changes in the trends in awareness, adoption and implementation of BIM across Scotland – perhaps on similar lines as the monitoring of the BIM Implementation Plan (Scottish Futures Trust, 2015). Such a survey should include larger and wider base in order to have a more representative character. Additionally, a review of project costs and comparison with the pre-BIM project profits may reveal cost savings which should, in turn, convince the private sector clients in the benefits of BIM implementation. Similarly, savings on carbon emissions and general efficiency can be compared in order to ascertain if BIM adoption and implementation has delivered on the promise.

## Acknowledgements

The authors would like to acknowledge the support by the Erasmus+ project ECOMED (575796-EPP-1-2016-1-ES-EPPKA2-KA; [www.ecomedbio.org](http://www.ecomedbio.org)).

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